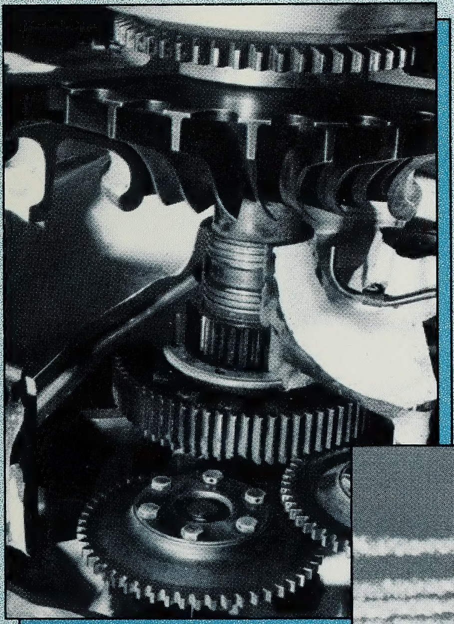
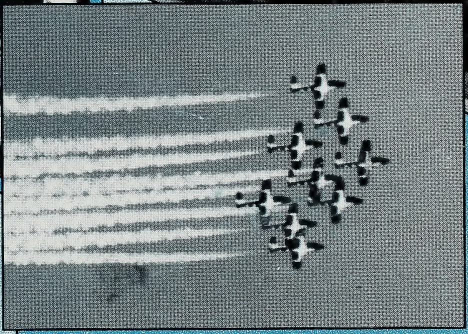
SCIENCE 7





MODULE 3:
FORCE AND MOTION

Distance Learning

Alberta
EDUCATION

Science 7

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ACKNOWLEDGEMENTS

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Science 7
Student Module
Module 3
Force and Motion
Alberta Distance Learning Centre
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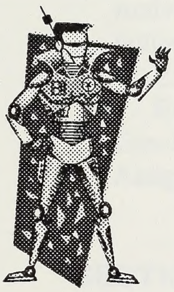

Welcome to Module 3!

We hope you'll enjoy your study of Force and Motion.

To make your learning a bit easier, a teacher will help guide you through the material.

So whenever you see this icon,

turn on your audiocassette and listen.

Contents

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OVERVIEW

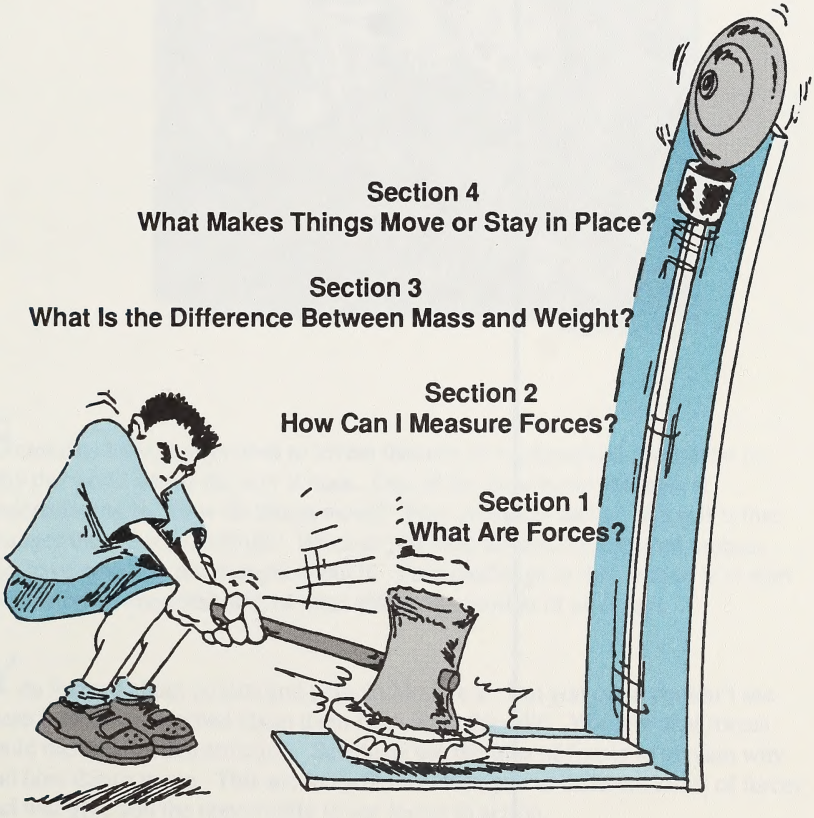
Turn to pages 140 and 141 of your textbook, *Science Directions 7* . The information and photographs on these pages introduce you to some of the things you will study in this module.

Module 3 provides you with the opportunity to study a variety of forces and to examine the effects of these forces on objects and materials. You will learn how to recognize and measure forces, and then focus on the effects of these forces in different applications.

A study of the causes and effects of friction and a study of motion in space are also part of Module 3.

From this module you will see how forces act on all things and how they affect you every day of your life.

Force and Motion



Evaluation

Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete four section assignments.

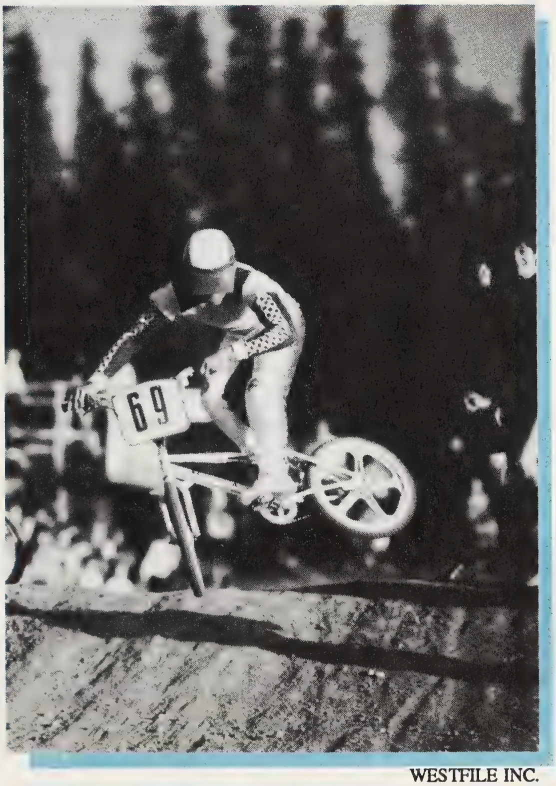
The assignment breakdown is as follows:

Section 1 Assignment	25%
Section 2 Assignment	20%
Section 3 Assignment	20%
Section 4 Assignment	35%
TOTAL	100%

Section

1

What Are Forces?



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Scientists have always tried to invent theories or explanations about how or why the world works the way it does. One of the most basic attempts at understanding is: How do things move? Why do things move? What is it that changes the motion of things? Because you have always experienced motion, you have probably not thought about it. Your challenge in this section is to start to develop an understanding of what affects the motion of an object.

You learned about pushes and pulls in Module 2. But you often couldn't see these forces; you learned about them from what they did. You saw that forces could move parts of a structure. Scientists use the idea of forces to explain why and how things move. This section will introduce you to different kinds of forces and will give you the opportunity to see forces in action.

Activity 1: Observing Forces

A parachute will allow you to float slowly toward the ground. A kite tugs at you, trying to pull you upward. An airplane allows you to soar across the sky. These motions are all caused by forces.

Force: a push or a pull

A change in motion is the evidence that tells you a **force** is acting. Can you explain why some things go up while others go down? This activity will help you examine the evidence in order to understand an explanation.

Do either Part A or Part B.

Part A involves looking at an illustration to find evidence of different forces and then answering some questions.

Part B involves answering the same questions as in Part A, but you will go outdoors to find evidence of different forces.

Part A

Look at the illustration on pages 142 and 143 of *Science Directions 7*; then answer the following questions.

1. Describe two examples of pushing forces. (What is being pushed? What is doing the pushing?) The following has been done for you.
   Example: *A teeter-totter is pushed upward. The rider pushes with his or her feet.*

   - ____________________
   - ____________________

2. Describe two examples of pulling forces. (What is being pulled? What is doing the pulling?)

   - ____________________
   - ____________________

Gravity: a force that pulls anything with mass towards anything else with mass

3. a. Describe two examples of the force of **gravity** at work.

   - ______________________________
   - ______________________________

   b. In which direction is this force acting?

   ____

4. a. Identify and describe evidence of forces that are lifting objects against the force of gravity.

   ____
   ____
   ____
   ____

   b. In which direction are they acting?

   ____

5. Identify and describe evidence of a force produced by springiness or elasticity.

   ____
   ____
   ____
   ____

6. Identify and describe evidence of a force that is slowing down the motion of an object.

   ____
   ____
   ____
   ____

7. Identify and describe evidence of a force that is stopping the motion of an object.

____

____

____

____

8. Identify and describe evidence of a force that is acting in a downward direction.

____

____

____

____

Discuss your answers with your learning facilitator.

Part B

Note: You do not need to complete Part B if you have already done Part A.

Read the questions for Part A; then go outside to find answers. If you have difficulty finding evidence, look at the illustrations for Part A to get some ideas.

Answer the questions for Part A.

Discuss your answers with your learning facilitator.

Activity 2: Experiencing Forces

There are many different types of forces around you. Clearly the force that makes a windmill turn is different from the force that makes a stick of dynamite explode.

Because of these differences, scientists have classified forces. Classifying forces helps scientists compare and contrast different forces. You will start by discovering and experiencing several types of forces in this activity.

7 Science Directions

This activity is based on the information present on pages 144 and 145 of *Science Directions 7* . You may wish to refer to these pages for additional information as you work through the various parts of this activity on the following pages.

Do all of Parts A, B, C, D, and F. Part E is optional.

For each of the following parts

- Read the Steps to Follow.
- Do each step and observe what happens.
- Note the direction of the force.
- Note whether the force is a push or a pull.

Part A

Materials You Need

- water
- pail or plastic container (3 to 5 L)
- table tennis ball or other air-filled ball
- steel ball or large marble

Steps to Follow

Step 1: Half fill the container with water.

Step 2: Drop a table tennis ball into the container of water. Record your observations in the chart which follows.

Step 3: Push the table tennis ball to the bottom of the container. Hold it for a short time and then release it. Record your observations.

Step 4: Using the steel ball, repeat steps 2 and 3.

Observations

Type of Ball	Observations When Dropped	Observations When Released Under Water
table tennis		
steel		

Questions to Answer

1. Was there any downward force shown in Part A?

   ____

   Describe the evidence for your answer.

   ____

   ____

   ____

2. Was there a force acting upward?

   ____

   Describe the evidence for your answer.

   ____

   ____

   ____

3. Was there a force acting sideways?

____

Describe the evidence for your answer.

____

____

____

Part B

Materials You Need

- penny
- scissors
- paper

Steps to Follow

Step 1: Cut out a piece of paper the size of a penny.

Step 2: Hold the paper in one hand and the penny in the other, both at waist height. Let them both drop at the same time. Record your observations.

Step 3: Place the piece of paper on top of the penny and drop them together from waist height. Record your observations.

Observations

Way of Dropping	Observations When Dropped
dropped apart	
dropped together	

Questions to Answer

4. Was there any downward force shown in Part B?

   ____

   Describe the evidence for your answer.

   ____

   ____

   ____

5. Was there a force acting upward?

   ____

   Describe the evidence for your answer.

   ____

   ____

   ____

6. Was there a force acting sideways?

   ____

   Describe the evidence for your answer.

   ____

   ____

   ____

Part C

Materials You Need

- paper clip
- penny
- index card
- magnet

Steps to Follow

Step 1: Place the paper clip on the index card.

Step 2: Hold the magnet under the card and move the magnet. Record your observations.

Step 3: Place a penny on the index card.

Step 4: Hold the magnet under the card and move the magnet. Record your observations.

Observations

Object	Observations When Magnet Moved
paper clip	
penny	

Questions to Answer

7. Was there any downward force shown in Part C?

   ____

   Describe the evidence for your answer.

   ____

   ____

   ____

8. Was there a force acting upward?

   ____

   Describe the evidence for your answer.

   ____

   ____

   ____

9. Was there a force acting sideways?

   ____

   Describe the evidence for your answer.

   ____

   ____

   ____

Part D

Materials You Need

- paper
- wool or fur
- unused plastic comb or plastic rod
- scissors

Steps to Follow

Step 1: Cut up a few tiny pieces of paper. Push them around gently with a clean plastic comb or plastic rod. Record your observations in the following chart.

Step 2: Rub the comb or rod on wool or fur. Again put the comb or rod near the pieces of paper. Record your observations.

Observations

Object	Observations of Pieces of Paper
plastic unrubbed	
plastic rubbed	

Questions to Answer

10. Was there any downward force shown in Part D?

    ____

    Describe the evidence for your answer.

    ____

    ____

    ____

11. Was there a force acting upward?

    ____

    Describe the evidence for your answer.

    ____

    ____

    ____

12. Was there a force acting sideways?

    ____

    Describe the evidence for your answer.

    ____

    ____

    ____

Part E (Optional)

Materials You Need

- metre stick
- rubber ball
- rigid foam ball

Steps to Follow

Step 1: Place one end of a metre stick on the floor and drop a rubber ball from a height of 1 m. Use the metre stick to measure how high the ball bounces. Record your observations.

Step 2: Repeat step 1 with the foam ball. Record your observations.

Observations

Type of Ball	Height of Bounce
rubber ball	
rigid foam ball	

Questions to Answer

13. Was there any downward force shown in Part E?

____

Describe the evidence for your answer.

____

____

____

14. Was there a force acting upwards?

____

Describe the evidence for your answer.

____

____

____

15. Was there a force acting sideways?

____

Describe the evidence for your answer.

____

____

____

Part F

Materials You Need

- piece of rug or piece of heavy cloth
- piece of wood
- two bricks or other object with rough surface

Steps to Follow

Step 1: Lay a piece of rug on the floor, and hold onto one end. Push a brick from one end of the rug to the other. Record your observations.

Step 2: Push a brick across a piece of wood. Record your observations.

Step 3: Push two bricks stacked one on top of the other over each surface. Record your observations.

Observations

Surface Used	Observations For One Brick	Observations For Two Bricks
pushed on rug surface		
pushed on wood surface		

Questions to Answer

16. Was there any downward force shown in Part F?

____

Describe the evidence for your answer.

____

____

____

17. Was there a force acting upward?

____

Describe the evidence for your answer.

____

____

____

18. Was there a force acting sideways?

____

Describe the evidence for your answer.

____

____

____

Discuss your answers with your learning facilitator.

Activity 3: Classifying Forces

The forces you experienced in Activity 2 were gravity, friction, electrostatics, magnetism, and buoyancy. Many of these forces affect you every day.

Gravity

Matter: anything that has mass and occupies space
All gases, liquids, and solids are matter.

Mass: the amount of matter in an object
Mass is usually measured in grams and kilograms. An object's mass remains the same whether the object is on Earth or in space.

The Earth's gravity is the force that keeps your feet on the ground. When you drop a ball, or when something falls, it is because gravity pulls the object toward the Earth. Gravity acts on everything on Earth; living things and non-living things. All of these – your body, tiny microorganisms, doorknobs, this paper – are made of **matter**. Matter is anything that takes up space and has **mass**. Gravity is the force that pulls anything that has mass toward any other thing that has mass.

In Part A of Activity 2, gravity was the force that pulled the table tennis ball and steel ball from your hand into the container of water. In Part B, gravity pulled the penny and the paper from your hands to the floor. In Part E, gravity pulled the rubber ball and the rigid foam ball to the floor.

Friction

Friction: a force that results when the surface of an object moves against the surface of another object

Friction is the force that always resists the motion of one object moving against another. For example, on a steep slope, gravity helps a skier to ski swiftly downhill. But friction between the skis and the snow acts in the opposite direction and tends to slow the skis down. Without friction, the skier would not be able to turn, slow down, or stop!

Friction is an interesting force because you only notice it when it interferes with another force or slows down motion caused by another force. For example, you want friction on your bicycle brakes that will slow you down against the pull of gravity on a steep hill. In other situations you want as little friction as possible. The less friction there is on the chain, the easier it is to peddle the bicycle. Oil is used to reduce the friction of the chain against the gears, but don't get oil on the brakes.

Generally, there is more friction between rough surfaces. You observed the difference between pushing a brick across a rug and across wood. Also, friction is increased when surfaces are pressed together with more force. You observed this when you added a second brick and pushed them across the rug.

When you dropped a penny and a piece of paper, you observed that the penny dropped faster than the paper. Both the penny and the paper are pushing against the air as they drop to the ground. Due to friction with the air, the paper falls more slowly than the penny.

Electrostatics

Electrostatic force: the electricity produced when two surfaces are rubbed against each other

Static: the common word for electrostatic force

Friction is not the only force that results when surfaces are rubbed together. Rubbing two different kinds of materials against one another may produce a form of electricity. Scientists call this force, **electrostatic force**. You may call this force by its common name, **static**.

After you rubbed plastic with wool or fur, small pieces of paper were attracted to the plastic. Think back to other experiences you have had with static electricity. This force can make your clothes cling to you. Have you ever noticed that sometimes your hair is attracted toward your brush as you brush your hair?

When electrostatic forces build up to a high level between two objects that are too big to be pulled together, a spark of electricity jumps across the space between the objects. The static shock you get from a doorknob after walking across a wool carpet is an example of this. The most spectacular demonstration of electrostatic sparking is lightning.

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Science Directions

For more information on electrostatic forces, refer to pages 171 to 173 of the textbook.

Magnetism

Magnetism: a characteristic of some materials that causes them to be attracted to some metals Materials that have this characteristic are called magnets.

Magnetic force: a force that acts on some objects near a magnet

Magnetism causes forces that push or pull some objects around a magnet. If a magnet can move something without touching it, the force is said to be magnetic.

In Part C of Activity 2, there was a **magnetic force** between the magnet and the paper clip. There was no magnetic force between the magnet and the penny.

For more information on magnetism, refer to pages 173 to 175 of the textbook.

Buoyancy

Fluid: something that flows Gases and liquids are fluids.

Buoyancy: the upward force that fluids exert

If you have ever tried lifting a friend in a swimming pool, you would have noticed that your friend suddenly became much lighter. Objects seem lighter when they are immersed in water. All **fluids** exert an upward force called **buoyancy**.

In Part A of Activity 2, the upward buoyant force on the table tennis ball was greater than the downward force of gravity, so the ball moved upward when released from the bottom of the container of water. The upward buoyant force on the steel ball was less than the downward force of gravity, so the steel ball remained at the bottom of the container of water when released.

See the illustrations on pages 175, 176, and 177 of the textbook for other examples of buoyant forces acting on objects in water and in air.

For the following questions, name the forces that are affecting the motion. Choose from the following list. You may use each force more than once. You may use more than one force for each example.

- gravity
- friction
- electrostatic force
- magnetism
- buoyancy

1. Bernie has two nickels. He touched them both with a magnet. The magnet picked up one nickel but not the other. Bernie noticed that the nickel picked up by the magnet had been minted in 1979, and the nickel not picked up by the magnet had been minted in 1989.

   a. List the force or forces present in this example.

   ____

   ____

b. What evidence is there for each of these forces?

2. Sarah cut two identical squares of aluminum foil. She rolled one square into a ball and folded up the edges of the other square to make a small container. She then placed them both on the surface of a container of water. The ball shape sank to the bottom; the container shape floated on the surface of the water.

   a. List the force or forces present in this example.

   b. What evidence is there for each of these forces?

3. Ernst placed a book on one end of a breadboard. He slanted the breadboard by lifting the end the book was sitting on. When he lifted the end of the breadboard 10 cm, nothing happened to the book. When he lifted the end of the breadboard 30 cm, the book slid to the lower end of the breadboard.

   a. List the force or forces present in this example.

b. What evidence is there for each of these forces?

Check your answers with your learning facilitator.

Follow-up Activities

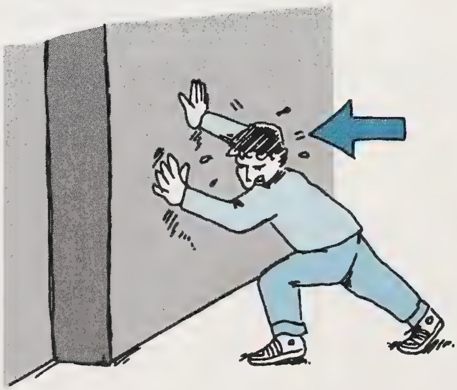
If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

A **force** is a push or a pull that

- makes things start to move
- makes things move faster
- slows things down
- stops things from moving

Sometimes the force is too small to cause motion. For example, you can push on a concrete wall without moving the wall. You are using force, but not enough force to cause the wall to move.



There is always a direction involved with a force. When you pull a wagon, the direction is obvious because the force is in the same direction that the wagon is moving.

You cannot see forces. The idea of a *force* is useful to explain why things move the way they do. Things move and stop moving for many reasons. The following forces cause some of these changes in motion.

Types of Forces

- gravity
- friction
- electrostatics
- magnetism
- buoyancy

Here is a brief description of each of these forces:

Gravity is what pulls things toward the Earth. When things fall, they are being pulled towards the centre of the Earth by the force of gravity.

Friction is what slows things down. When surfaces rub together, they tend to slow down because of the force of friction. When you roll a ball on level ground, it eventually stops moving. If you push a rubber duck into a pond, the duck will slow down and stop moving. Spacecraft that are returning to Earth heat up when they enter the atmosphere because of the force of friction between the surface of the spacecraft and the air.

Electrostatic forces are caused by rubbing different materials together. Plastic and wool are good examples. Electric charges are built up that pull the materials together or push them apart. If the charges build up too high and the materials cannot move because of other forces, the electricity will jump from one material to the other, causing a spark.

Magnetic forces are caused by magnets. Some metals are attracted to magnets. If you have two magnets, some ends pull together and other ends push apart. Magnetic forces are used to keep some doors closed.

Buoyancy is an upward force that makes some things float. Buoyant forces always make things feel lighter because they work in the opposite direction to gravity. Buoyancy occurs when things are placed in fluids. Fluids are liquids and gases. Boats float on water because of buoyancy. Helium balloons float in air because of buoyancy.

There are more forces than these, but these will give you a good start in understanding why things move.

Do the three extra help demonstrations which follow, and then explain why each is evidence of the unseen forces at work.

Elastic Forces

Materials You Need

- rubber band
- ruler
- 100 g mass

Steps to Follow

Step 1: Hang a rubber band from a doorknob.

Step 2: Measure the length of the rubber band and record its length in centimetres.

Step 3: Hang a 100 g mass on the bottom end of the rubber band.

Step 4: Measure the length of the rubber band with the 100 g mass and record its length in centimetres.

Observations

length of rubber band = __________ cm

length of rubber band and 100 g mass = _________ cm

Questions to Answer

1. What force caused the rubber band to stretch?

____

2. What was the direction of the force?

____

Magnetic Forces

Materials You Need

- paper clip
- thread
- tape
- magnet

Steps to Follow

Step 1: Tie about 20 cm to 30 cm of thread to the paper clip.

Step 2: Tape the other end of the thread to a table, somewhere near the table's centre.

Step 3: Using the magnet, try to move the paper clip, but don't touch it with the magnet.

Step 4: Now see if you can lift the paper clip off of the table by using the magnet, but without touching it with the magnet.

Diagram

- Draw a diagram in the following box to show what you did.

Questions to Answer

3. What force moved the paper clip **away** from the table?

4. What was the direction of the force?

5. What force moved the paper clip **toward** the table?

Buoyant Forces

Materials You Need

- several pennies
- large container (4 L)
- water
- small plastic lid

Steps to Follow

Step 1: Half fill the large container with water.

Step 2: Float a small plastic lid on the water.

Step 3: Place as many pennies as you can on the lid so that it still floats holding the pennies.

Step 4: Continue to add more pennies.

Step 5: Record how many pennies you were able to add before the lid sank or tipped.

Observations

number of pennies that floated = __________

Questions to Answer

6. What force made the pennies and the lid float?

____

____

7. What was the direction of the force?

____

8. Why did the lid sink or tip when too many pennies were added?

____

____

Discuss your answers with your learning facilitator.

Enrichment

__Balanced forces:__ two forces of equal strength acting on an object in opposite directions

__Unbalanced forces:__ forces of different strengths acting on an object in opposite directions Unbalanced forces cause a change in the motion of the object they are acting on.

7 Science Directions

Scientists explain changes in motion by the idea of forces. You cannot always see forces, but you can see their effects. Whenever there is a change in motion, you can explain it by describing the forces acting on the object. To help describe how forces act on an object, you need to know the direction and strength of the forces and to understand whether they are **balanced forces** or **unbalanced forces.**

Read pages 146 and 147 of *Science Directions 7* regarding the topic Direction and Strength of Forces. Answer the following questions.

1. Look at the photograph of the weightlifter shown on page 147 of the textbook. Whether he is able to lift the barbells higher or not depends on the balance between his upward force and the downward force of gravity.

   Sketch the weightlifter in the following space. Draw arrows to show that his lifting force is greater than the force of gravity pulling the barbells down toward the Earth.

2. Now look at the illustration of the man pulling the boy on the toboggan, on the bottom of page 147 of the textbook. The toboggan has started to move and is gathering speed as it is pulled.

   a. Are the forces balanced or unbalanced?

   ____

b. How do you know?

____

____

c. What force is represented by the arrow pointing to the left?

____

3. Now it is your turn to think up an example. Think of an example of two forces acting in opposite directions. Choose from the following forces.

- gravitational force
- frictional force
- electrostatic force
- magnetic force
- buoyant force

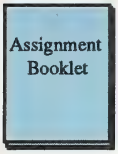
Draw a sketch of the example you have chosen. Use arrows to show the direction and size of the forces. Label your sketch to show which two forces you are illustrating.

Discuss your answers with your learning facilitator.

Conclusion

This section introduced you to the idea of forces. The idea of forces is used to explain why things move. Forces are pushes and pulls, but a better understanding is to classify forces into categories such as gravitational, magnetic, frictional, buoyant, and electrostatic forces.

You cannot see forces. You can infer that a force is present by observing how things move. Remember, all forces have a direction. Most things have several forces acting on them at the same time.



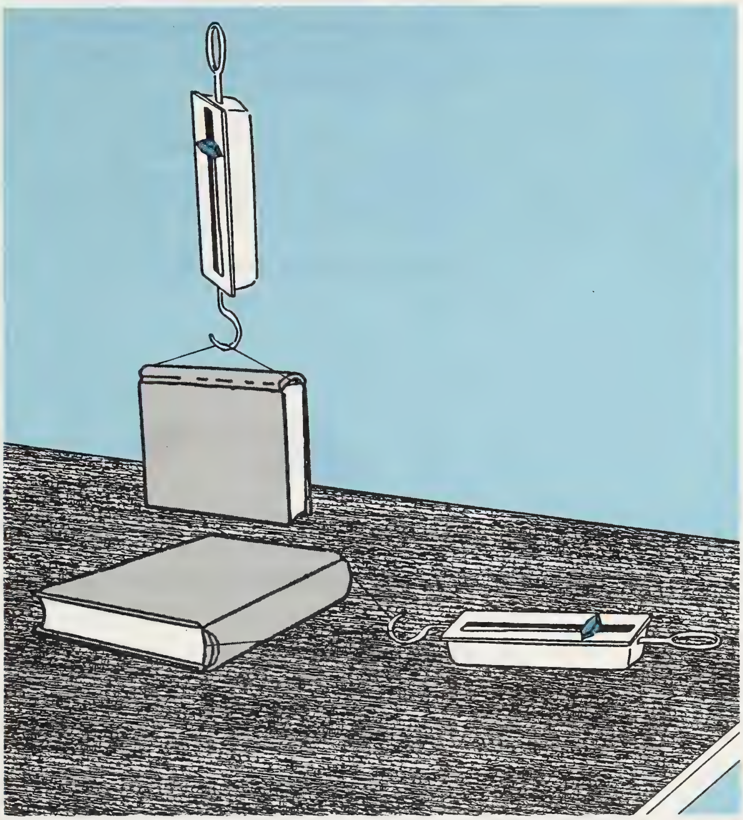
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

Section

2

How Can I Measure Forces?



Which of the following do you think requires the most force?

- Lifting a book?
- Sliding a book across a table?
- Sliding a book across a carpet?

To find the answer, you must measure the force required for each task. In this section you will build a force meter – an instrument used for measuring forces. By using a force meter, you can find out which task requires the most force, and you will start to understand more about the nature of force.

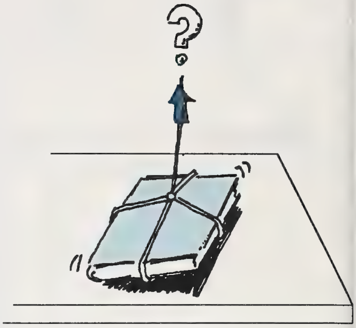
Activity 1: Building a Force Meter

Suppose you wanted to measure the amount of force required to move a book in each of the three ways shown. How would you do this? Can you construct a force measurer (or force meter) that will measure these forces?

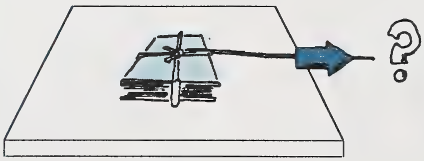
Force meter: an instrument for measuring force

Can you construct a **force meter** that can measure forces needed to move other objects that you find in the room?

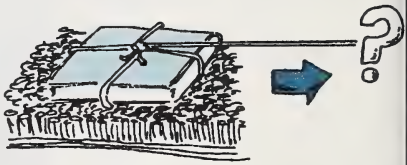
You should be able to do this with some help.



lifting a book



sliding a book across a table



sliding a book across a carpet

Getting Started

To design and build a force meter you need to think about

- its function – Your force meter will be used to measure the strength of forces required to move books and other objects found in the room.
- its structure and design – You will need to decide what different parts to use in your force meter and how you will join them together.

The following questions will help you get started. Jot down some ideas for each question.

1. For a force meter to work, a part of the meter has to be moved by the force. For a large force it should be moved quite a bit; for a small force it should be moved just a little. Some springy or elastic material might be used. What can you think of that is springy or elastic?

2. You may want to have a way to pull some things and push others. What could you attach to your meter that would help it push or pull?

3. Sometimes you may need to measure forces that are fairly weak; other times you may need to measure forces that are fairly strong. Can you think of a way to make adjustments to your force meter so that it can measure both strong and weak forces?

Some Design Ideas

7
Science Directions

You can often learn from other people's designs. Read pages 148 and 149 of *Science Directions 7*. Examine what Greg and Debra did to build their force meters.

Greg had no difficulty in measuring the amount of force needed to push an object with his meter. However, he did have problems when he wanted to measure the amount of force needed to pull an object. Can you think of any suggestions that would have helped him?

Debra marked a scale on her force meter. To measure the amount of force needed to pull an object, she attached the object to the hook. To measure the amount of force needed to push an object, she pushed on the object with the wooden dowel from the tip end. By using thicker and thinner elastics, she was able to measure strong and weak forces.

Steps To Follow

Step 1: Design and build your own force meter with any available materials you wish to use.

Step 2: Test your meter by pushing and pulling on some small objects. Next, try your meter on some larger objects that need more force. The springy material should move a greater distance for large forces than it does for small forces. (A new design seldom works the first time. Be proud of yourself if your meter works the first time. It won't be easy!)

Step 3: If your force meter did not work well, make changes to improve your design.

Step 4: Try your force meter on the following three tasks.

a. Use your force meter to lift a book. Use a piece of tape or a pencil to mark the distance the force meter moved while lifting the book.

b. Now use your force meter to slide a book across a table. Mark the distance that the force meter moved while sliding the book across the table.

c. Now use your force meter to slide a book across a carpet. Mark the distance that the force meter moved while sliding the book across the carpet.

Step 5: Use the force meter to lift a 100 g mass or one of the 100 g test bags you prepared in Module 2. Make a mark on the force meter to show the force needed to lift the 100 g mass.

Now answer the following questions.

4. From step 2, list the three tasks from most force required to least force required.

______________	______________	______________
most force		least force

5. a. Did the tasks require more force or less force than lifting the 100 g mass?

____

b. How do you know?

____

____

____

Discuss your answers with your learning facilitator.

Activity 2: Measuring Units

Calibrate: to mark a scale of units, such as centimetres or newtons, on a measuring device, such as a ruler or force meter

Newton: the standard SI unit for measuring a force

Your force meter helped you compare forces, but you were not able to give the forces a number. That is because you did not calibrate the force meter. To **calibrate** a meter you must mark a scale of units. A ruler can be calibrated into units called millimetres or centimetres. A thermometer is calibrated into degrees.

The standard unit for measuring force is the **newton**. The symbol is N. A capital letter is used because the newton is named after a person, Sir Isaac Newton. Our ideas about how forces cause motion are based on his ideas.

To get an idea of what a newton of force feels like, consider this. It takes about 1 N (one newton) to hold up a mass of 100 g. You marked this on your force meter. You could calibrate your force meter by lifting a 200 g mass, then a 300 g mass, and so on. You could then label the marks as *1 N*, *2 N*, *3 N*, and so on.

If you have ever had braces on your teeth or used a retainer to help straighten your teeth, you will be interested to know that Dr. Gary Faulkner of the University of Alberta and a team of co-workers developed a model of the jaw and its biting muscles. Then they measured the strength of the force of each muscle with a force meter. Dr. Faulkner and his co-workers used the information from the model to make improved braces for teeth.

7 Science Directions

Turn to page 153 of *Science Directions 7* for more information on the importance of using standard units and to see diagrams of a jaw model and braces.

Part A is optional. Students may do it if they wish. However, students must do Part B.

Part A involves calibrating your own force meter. This part is optional.

Part B involves using a calibrated force meter (either your own or a manufactured one) to measure the strength of the force you use on some objects. Before you do the actual measuring, you are to estimate the strength of each force. To help you make your estimates, think back to the objects you tested while making your force meter in Activity 1. Would the objects in this activity be easier or more difficult to push or pull than the objects you worked with in Activity 1? Also, in Part B as you measure the strength of the force you are using on each object, think about the direction it is moving in and how you would draw an arrow to represent the force.

Part A: Calibrating a Force Meter (Optional)

Steps to Follow

7 Science Directions

Step 1: Start by marking *0* at the place on your force meter that shows that no force is being applied to the force meter. Check the illustration on page 154 of *Science Directions 7*.

Step 2: Lift a 100 g mass with your force meter. Mark how far the force meter moves. Label this position *1 N* (one newton).

Step 3: Lift a 200 g mass with your force meter. Mark how far the force meter moves. Label this position *2 N* (two newtons).

Step 4: Lift a 300 g mass with your force meter. Mark how far the force meter moves. Label this position *3 N* (three newtons).

Step 5: Repeat until you have your force meter calibrated to 10 N. This will require using a 1000 g mass.

Share your answers with your learning facilitator.

Now that your force meter is calibrated, do Part B.

Part B: Using a Force Meter

Note: Students must do Part B.

Steps to Follow

7 Science Directions

Step 1: Look at the illustrations in Activity 1 and the photographs on pages 150 and 151 of the textbook. Make an estimate of the strength of the force needed for lifting a book. Do your estimate in newtons. Record your estimates in the observation chart which follows.

Step 2: Measure the strength of the force and record your result.

Step 3: Draw an arrow to show the direction of the force that you applied.

Step 4: Repeat for each of the other actions to complete the chart.

Observations

Action	Estimated Force	Measured Force	Direction of Force
lifting a book			
sliding a book across a table			
sliding a book across a carpet			
turning on a light switch			
opening a sliding door			
turning a doorknob			
opening a refrigerator door			

Questions to Answer

1. List the three actions that required the most force, and then list the three actions that required the least force.

   most force
   - ____________________
   - ____________________
   - ____________________

   least force
   - ____________________
   - ____________________
   - ____________________

2. Describe how you could use a force meter to measure each of the following:

   a. the force of gravity on an object

   ____

   ____

   b. the force of friction on an object

   ____

   ____

   c. the force of a magnet on an object

   ____

   ____

d. the force of buoyancy on an object

____

____

Discuss your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Spring scale: a type of force meter
It is an instrument used for measuring the strength of a force.

Scale: the equal divisions marked on a measuring device

You can use a force meter (**spring scale**) to measure force. The spring pulls against the force. By noting how much the spring stretches, you can find out the strength of the force pulling on it.

The lines and numbers on the force meter form a **scale**. All measuring devices have scales. On a ruler, the scale is marked in centimetres. On a thermometer, the scale is marked in degrees. On a force meter, the scale is marked in newtons.

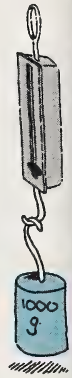
Force is measured in units called newtons. The symbol is N. A newton is the force needed to lift an object with a mass of about 100 g. To get an idea of what a newton of force feels like, hold an apple or an orange. An average apple or orange has a mass close to 100 g. You can also try to twist open a doorknob. It takes about 10 to 15 N to twist open an ordinary doorknob.

Materials You Need

- force meter (spring scale) calibrated in newtons
- paper clip
- two magnets
- 1000 g mass

Questions to Answer

Use the spring scale and the 1000 g mass to answer the following questions.



1. Hook the spring scale onto the 1000 g mass. Lift until the spring scale reads 8 N. Did the 1000 g mass lift off the table?

____

2. How many newtons of force are required to lift the 1000 g mass?

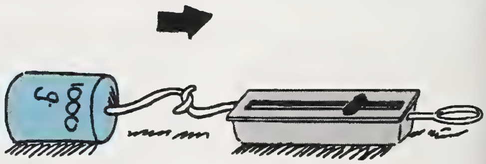
____

3. Apply 1 N of force in an attempt to drag the 1000 g mass across a table. Will the mass move?

____

4. How many newtons of force are needed to drag the 1000 g mass across the table?

____

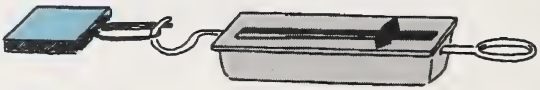


5. What force is the spring scale pulling against?

____

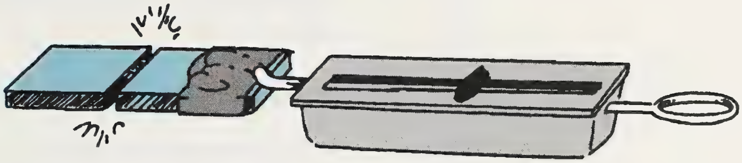
6. Attach a paper clip to the spring scale. Touch a magnet to the other end of the paper clip. Pull the spring scale. How many newtons of force are needed to pull the paper clip away from the magnet?

____



7. Tape the spring scale to one end of a magnet. Touch the other end of the magnet to the end of a second magnet that attracts it. Pull the spring scale. How many newtons of force are needed to pull the magnets apart?

____



8. What force is the spring scale pulling against?

____

Discuss your answers with your learning facilitator.

Enrichment

7 Science Directions

In this activity you will measure the strength of a buoyant force acting on objects in water. Refer to The Force of Buoyancy on page 176 of the textbook for additional information, as needed.

Materials You Need

- large container (about 4 L)
- spring scale (force meter) calibrated in newtons
- water
- string
- stone
- three objects of your choice

Steps to Follow

Step 1: Suspend the stone from the spring scale and weigh it in newtons. Record the weight in the observation chart.

Step 2: Lower the stone into the water and weigh it again. Do not let the stone touch the bottom of the container. Record the weight in the observation chart.

Step 3: In the illustration on page 176 of the textbook

- the stone weighs 5 N in air
- the stone weighs 3 N in water
- the difference is 2 N

Therefore, the buoyant force on the stone is 2 N. Do this calculation for the stone you measured. Record your answer in the chart.

Step 4: Repeat steps 1 to 3 with three objects of your choice.

Observations

Object	Weight in Air (N)	Weight in Water (N)	Buoyant Force (N)
stone			

Questions to Answer

1. What is the main force acting on the stone before it is put in the water?

____

2. In which direction is this force acting?

____

3. What forces are acting on the stone when it is immersed in water?

____

____

4. In which direction is each of these forces acting?

____

____

____

5. Sketch the stone immersed in water; draw arrows showing the two forces acting on it.

6. A log has a weight of 200 N. What would the buoyant force be if the log was floating in a lake?

____

Give a reason for your answer.

____

____

Discuss your answers with your learning facilitator.

Conclusion

In this section you learned that a spring scale is used to measure forces. You also learned how to make a force meter and that the units of force are called newtons.

After doing the activities, you should be able to estimate and measure the strength of small forces.

This section started with the question, "Which of the following do you think requires the most force?"

- Lifting a book?
- Sliding a book across a table?
- Sliding a book across a carpet?

Now you know the answer to this question and how to find the answer to similar questions involving forces.

Assignment Booklet

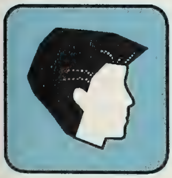
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3

What Is the Difference Between Mass and Weight?



Now that you have estimated and measured forces in the standard unit, the newton, you are ready to look closely at one specific force. In this section you will investigate the force that pulls on you all the time – gravity.

You will also compare mass and weight. In everyday language, these terms often mean the same thing. In science, mass and weight have very different meanings.

Activity 1: Measuring Weight and Mass

The Earth's gravity is the force that keeps your feet on the ground. When you drop a ball, or something falls, it is because gravity pulls down toward Earth. Earth's gravity always pulls down toward the centre of the Earth.

You know that the standard unit for measuring force is the newton. When you measure the force of gravity on an object, you use a spring scale (force meter) to measure the weight of an object in newtons. When you measure the **weight**, you are measuring the pull of gravity on the object.

Weight: the amount of force that is exerted on an object by gravity

See page 156 of *Science Directions 7*. Illustration (b) at the bottom of the page shows a spring scale (force meter). The force of gravity pulls down on the spring. By noting how far down the spring is pulled, you are measuring the object's weight in newtons.

To measure the **mass** of an object, you can use a **balance scale**. There are several types of balance scales. Illustration (a) on page 156 of the textbook shows a double pan balance. This type of balance scale is also called an equal arm balance. With a double pan balance, or equal arm balance, you can compare the mass of the object you are measuring with that of known masses. You put the object you are measuring on one pan of the balance scale and standard masses on the other pan. When the two pans are at the same level, the mass of the object is exactly equal to the total of the standard masses on the other pan. In illustration (a) on page 156, the apple is balanced with a 100 g mass. You could say the mass of the apple is 100 g.

Mass: the amount of matter in an object
Mass is usually measured in grams and kilograms. An object's mass remains the same whether the object is on Earth or in space.

Balance scale: an instrument used for measuring the mass of an object

The mass of an object is given in standard units such as grams and kilograms. The symbol for gram is g, and the symbol for kilogram is kg. The prefix *kilo* means 1000, so 1000 g is the same mass as 1 kg.

A common type of classroom balance scale is the triple beam balance. A triple beam balance is shown in the top left photograph on page 358 of *Science Directions 7* . To measure mass using a triple beam balance, you put the object on the pan and slide riders along the beams until both sides are balanced. Then you read the mass by adding the numbers from the scales on the three beams. A triple beam balance is convenient to use because it does not require a separate set of standard masses.

Another type of balance scale is the electronic balance, shown in the second photograph on page 358 of the textbook. Supermarkets use electronic balance scales to measure mass.

Mass tells you how much matter there is in an object. It does not always tell you how big the object is. A small heavy object (such as a brick) may have the same mass as a larger, light object (such as a feather pillow). The size of an object is called its **volume**.

Volume: the amount of space taken up by an object

The main points to remember are

- Weight is the force of gravity on an object.
- Weight is measured in newtons (N) using a spring scale.
- Mass is the amount of matter in an object.
- Mass is measured in grams (g) or kilograms (kg) using a balance scale.

Do either Part A or Part B.

Part A involves using actual equipment to measure mass and weight of some objects. All students are encouraged to do Part A. Only in circumstances where it is not possible to complete Part A are students to do Part B.

Part B gives some of the results a student obtained when measuring the mass and weight of some objects. Students are to complete the remainder of the observation chart and then answer some questions.

Part A

Note: You are encouraged to complete Part A, if possible.

In Part A you will measure the mass and the weight of some objects. When recording your answers, be careful to use the correct units (grams or newtons) along with the numbers.

Materials You Need

- spring scale
- balance scale
- set of standard masses calibrated in grams
- apple
- eraser
- book
- three objects of your choice

Steps to Follow

Step 1: Measure the mass of the apple.

Step 2: Record your answer in the observation chart. Write the number and the symbol of the correct unit.

Step 3: Measure the weight of the apple.

Step 4: Record your answer in the observation chart. Write the number and the symbol of the correct unit.

Step 5: Repeat steps 1 to 4 for the eraser and book and then for three objects of your choice.

Observations

Object Measured	Mass of Object	Weight of Object
apple		
eraser		
book		

Questions to Answer

1. What is used to measure the mass of each object?

____

2. What is used to measure the weight of each object?

____

3. Write the name and symbol for a unit of mass.

____

4. Write the name and symbol for a unit of weight.

5. What does *mass* mean?

6. What does *weight* mean?

Check your answers with your learning facilitator.

Part B

Note: You do not need to complete Part B if you have already done Part A.

The observation chart which follows gives some of the results a student obtained when measuring the mass and weight of some objects.

7. Complete the observation chart. When recording your answers, be careful to use the correct units (grams or newtons) along with the numbers.

Observations

Object Measured	Mass of Object	Weight of Object
banana	175 g	
container of yogourt		5 N
bag of sugar	2 kg	
box of salt		10 N
carton of crackers	250 g	
box of cereal		6.25 N

8. Answer questions 1 to 6 in Part A.

Check your answers with your learning facilitator.

Activity 2: What Is Gravity?

7 Science Directions

Read page 157 of *Science Directions 7* to learn about Isaac Newton's explanation of gravity. Also carefully read Weight and Mass on page 158 to find out how weight and mass are different.

Newton predicted that things would weigh less on the Moon since the Moon has much less mass than the Earth. But he was not able to check his prediction, since people did not travel to the Moon until the 1960s.

You are not able to travel to the Moon either, but with a little imagination and some observations that have been checked since Newton's time, you can pretend to blast off and help Newton test his ideas.

Do either Part A or Part B.

Part A involves following a student named Shelly as she takes a tour of the planets to learn about mass and weight.

Part B involves learning about mass and weight by making your own hypotheses and checking them out by taking a tour of the planets.

Part A: Interplanetary Exploration of Weight and Mass

Note: You do not need to complete Part A if you wish to do Part B.

7 Science Directions

Read the imaginary story, An Interplanetary Holiday, on pages 158 and 159 of *Science Directions 7* . This story is about how Shelly, a Grade 7 student, came to understand the difference between weight and mass. After reading her story and examining the record of the data she collected, answer the following questions.

1. Why do you think the weight of the silver block was different on each of the planets?

___

___

___

2. Why didn't the mass, as measured on the balance scale, change from planet to planet?

___

___

___

3. a. On which planet was the weight of the silver the greatest?

   ___

   b. On which planet was the weight of the silver the least?

   ___

4. a. Which planet has the greatest force of gravity? How do you know?

   ___

   ___

   ___

   b. Which planet has the smallest force of gravity? How do you know?

   ___

   ___

   ___

5. If you could travel to any of these planets to perform a high jump, which would you choose and why?

___

___

___

___

6. What would happen if gravity weren't holding things down? Write down all the benefits of gravity you can think of.

___

___

___

___

___

___

Discuss your answers with your learning facilitator.

Part B: Interplanetary Investigation – Challenging Your Thinking About Weight and Mass

Note: You do not need to complete Part B if you have already done Part A.

Pretend that you can visit any planet you choose. For your science fair project you decide to compare the mass and weight of an object on different planets.

First, you must decide which object to take. How about something fairly heavy? A boulder from the rock garden should do just fine.

Next, you must decide which planets to visit. To save time you decide to visit the three planets closest to Earth; Mercury, Venus, and Mars. A quick check in a reference book gives you the following information about the planets.

Planetary Data

Planet	Mass of Planet ($t \times 10^{20}$)	Distance from the Sun (Gm)	Length of Day (h)
Mercury	3	58	1400
Venus	48	108	5800
Earth	60	150	24
Mars	6	228	24

You may not be familiar with some of the units in the previous chart. The units have been selected to make it easier to compare the measurements.

Here is how to make more sense out of the numbers in the chart.

- For the mass of the planet, add 20 zeros to the number, and the answer is in tonnes.
- For the distance from the Sun, add 9 zeros and the answer will be in metres. (The symbol Gm stands for gigametres: 1 Gm is equal to one billion metres.)
- The length of a day is in hours. The symbol h is used for hours.

Data: factual information (The word "data" is plural; the singular is "datum.")

Hypothesis: an idea or model that provides a possible explanation of why something occurs in the natural world

Before leaving Earth to collect **data**, you should make an **hypothesis**. What is different about the planets that might affect the mass of your boulder? The reference gave you information to compare the following variables:

- mass of each planet
- distance of each planet from the sun
- length of a day on each planet

Which of these variables do you think would affect the **mass** of your boulder? Will any of these make a difference? Remember, you measure the mass of objects with a balance scale, and the units are grams.

If you think that length of a day will affect the mass of the objects, you should write:

Hypothesis: The length of day on a planet will affect the mass of an object.

You could be more specific and write your hypothesis as follows:

Hypothesis: The mass of an object will be greater on planets that have longer days.

For this hypothesis you have been told how the variables are related. Remember, controlled experiments need to be done to determine if an hypothesis is correct or not. If evidence does not support an hypothesis, the hypothesis may need to be changed.

Questions for Investigation

7. Now it is your turn. Write your own hypothesis for what you think will most likely affect the **mass** of an object when measured on different planets.

   Your Hypothesis (mass of boulder):

   ____

   ____

8. Scientists generally have good reasons for their hypotheses. Do you have any reasons for yours? It may be difficult for you to give good reasons, but try anyway. Remember, scientists are always prepared to change their hypotheses, so you shouldn't worry if yours requires changing.

   Reasons for Hypothesis:

   ____

   ____

9. Since a trip to the planets is fairly expensive, you should also measure the **weight** of the boulder on each planet. Of course, you measure the weight using a spring scale and the units are newtons(N).

   Which variable do you think would affect the weight of an object when measured on different planets? Would any of these make a difference?

   - mass of each planet
   - distance of each planet from the Sun
   - length of a day on each planet

   Your Hypothesis (weight of boulder):

   ____

   ____

   Reason for Hypothesis:

   ____

   ____

Observations

Now you are ready to make some measurements and check your hypothesis. You will have to use your imagination since a space ship is too big to work within your classroom or your home.

Here is a close approximation of the measurements you would have collected if a trip to the planets was actually possible.

Weight and Mass of a Boulder on Different Planets

Planet	Mass of Boulder in Grams (g)	Mass of Boulder in Kilograms (kg)	Weight of Boulder in Newtons (N)
Mercury	10 000	10	36
Venus	10 000	10	86
Earth	10 000	10	100
Mars	10 000	10	40

Use the information gained so far in Part B to answer the following questions.

10. Did the mass of the boulder change when it was measured on different planets?

____

____

11. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. The mass of an object is larger if measured on a planet with a larger mass.

    b. The mass of an object is smaller if measured on a planet with a larger mass.

    c. The mass of an object is not affected by the mass of the planet it is on.

12. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. The mass of an object is larger if measured on a planet farther from the Sun.

    b. The mass of an object is smaller if measured on a planet farther from the Sun.

    c. The mass of an object is not affected by the distance of the planet from the Sun.

13. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. The mass of an object is larger if measured on a planet with a longer day.

    b. The mass of an object is smaller if measured on a planet with a longer day.

    c. The mass of an object is not affected by the length of a planet's day.

14. Did the weight of the boulder change when it was measured on different planets?

____

____

15. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. An object weighs more on a planet with a larger mass.

    b. An object weighs less on a planet with a larger mass.

    c. The weight of an object is not affected by the mass of the planet it is on.

    d. There is no clear pattern to the observations.

16. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. An object weighs more on a planet farther from the Sun.

    b. An objects weighs less on a planet farther from the Sun.

    c. The weight of an object is not affected by the distance of the planet from the Sun.

    d. There is no clear pattern to the observations.

17. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. An object weighs more on a planet with a longer day.

    b. An object weighs less on a planet with a longer day.

    c. The weight of an object is not affected by the length of a planet's day.

    d. There is no clear pattern to the observations.

18. You may remember that the first part of Sir Isaac Newton's laws of gravitation stated that:

    An object that has a large mass has a greater force of gravity than an object that has less mass.

    a. Do the observations from your imaginary trip to the planets agree with this statement?

    ____

    b. Give a reason for your answer.

    ____

    ____

Check your answers with your learning facilitator.

Activity 3: Gravity in Space

7 Science Directions

Read the information on page 160 of *Science Directions 7*. The data from the diagram can be shown in chart form as follows.

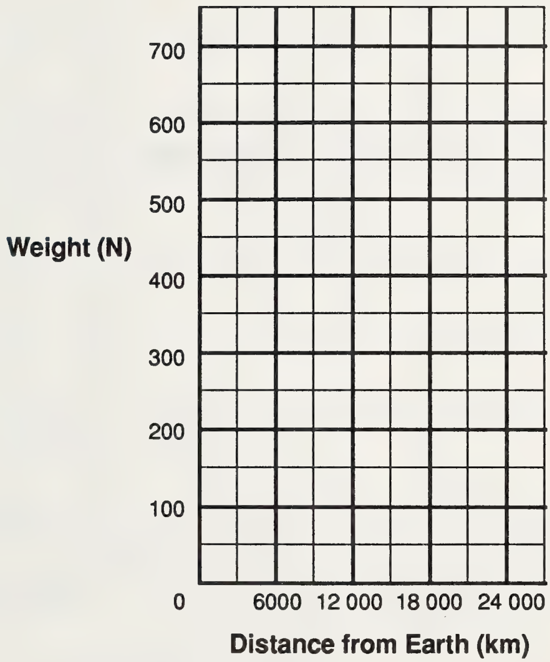
Distance from the Earth Versus Mass and Weight

Distance from Earth (km)	Mass of Astronaut (kg)	Weight of Astronaut (N)
0	68	680
6 000	68	170
12 000	68	76
18 000	68	43
24 000	68	27

1. The data can also be shown in graph form.

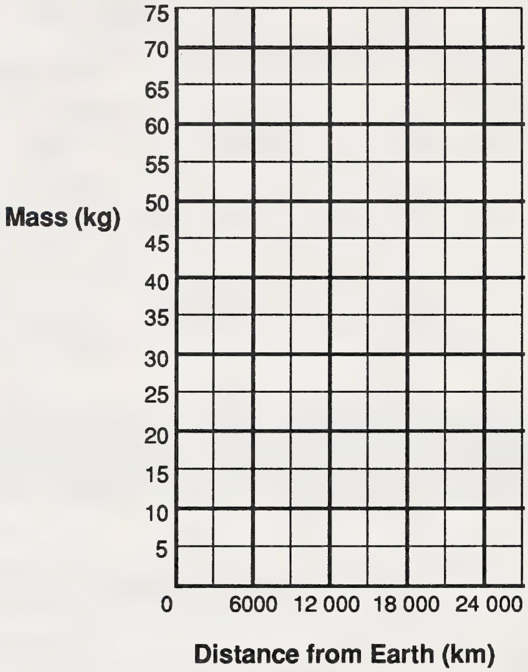
   a. Make a graph to show how an astronaut's weight changes as the distance from Earth increases.

Graph One – Weight and Distance



b. Make a second graph to show the relationship between distance from Earth and an astronaut's mass.

Graph Two – Mass and Distance



c. What is the relationship between an astronaut's weight and the distance from Earth?

____

____

____

____

d. What is the relationship between distance from Earth and an astronaut's mass?

Newton thought that gravity acted between all objects throughout the universe. All the evidence that has been gathered since then supports this idea. All the evidence to date supports Newton's other ideas about gravity, too. Here is a summary of Newton's ideas about gravity:

- The force of gravity acts between every pair of objects in the universe.
- The greater the mass of the objects, the greater the force of gravity between them.
- The greater the distance between the objects, the smaller the force of gravity between them.

2. Think about an astronaut on a trip from the Earth to the Moon. As the astronaut moves away from the Earth, the force of gravity between the astronaut and the Earth becomes smaller. But gravity acts between all objects in the universe. As the astronaut moves toward the Moon, the force of gravity between the astronaut and the Moon becomes greater.

   There is a special point, about nine-tenths of the way to the Moon, where the pull of the Earth's gravity is balanced by the pull of the Moon's gravity. At that point, the astronaut experiences a force of gravity of 0 N. Why do you think this special point is so much closer to the Moon than it is to the Earth?

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

The idea of mass is very useful because it tells you how much matter an object is made of. Mass is measured with a pan balance. The units of mass are grams or kilograms.

If a pizza has a mass of 1000 g on Earth, the mass of the pizza will also be 1000 g on the Moon or in space. The only way to change the mass of the pizza is to eat some of it. This will reduce the mass of the pizza because there will be less matter in the pizza after you have eaten some of it. If you eat all of the pizza, its mass will be zero.

For convenience, the mass of large things is recorded using the unit kilograms. One kilogram is the same as one thousand grams (1 kg = 1000 g).

If you weighed the same pizza on the surface of the Earth, it would have a weight of 10 N. This tells you that the Earth is pulling the pizza with a force of 10 N. If you could take the pizza up in the air and then into space, the pizza would weigh less and less. This is because, as it moves farther away from the Earth, the Earth's pull (force of gravity) on the pizza would be less and less.

If you travelled all the way to the Moon, the Moon would start to pull on the pizza. Because the Moon has a much smaller mass than the Earth, the force of gravity of the Moon is much less than the Earth's force of gravity. The weight of the pizza on the Moon would be about 1/6 of what it is on Earth. The pizza would weigh about 1.7 N on the Moon (10 divided by 6 is about 1.7).

For each of the following, circle the T if the statement is true. If the statement is false, circle the F, and rewrite the statement on the line beneath to make the statement true.

T F 1. Gravity acts between some objects.

____

T F 2. Mass and weight are both measured in kilograms.

____

T F 3. Mass remains the same wherever you are.

____

T F 4. Forces are measured in newtons.

____

T F 5. Weight is a measure of the mass of an object.

____

T F 6. A balance scale is used to measure mass.

____

T F 7. A scale calibrated in grams is used to measure weight.

____

T F 8. Weight increases as you move away from the Earth's surface.

____

T F 9. Mass is a force.

____

For questions 10 to 15, fill in the blank with a word or phrase that correctly completes the sentence. Use words from the following list. Use each word only once. You will not use all of these words.

Word List

decrease	increase
force	less
grams	mass
graph	newtons
gravity	scale
greater	weight

10. ________________ changes as the force of gravity changes.

11. If the distance between two objects is increased, the force of gravity between the objects will ____________.

12. The weight of an object will be more if it is measured on a planet that has ________________ mass.

13. A pan balance can be used to measure ________________.

14. Mass is reported in units called ________________.

15. A ________________ can be used to show a pattern between two sets of data.

Check your answers with your learning facilitator.

Enrichment

You may choose to do only Part A or Part B, but you may do both Part A and Part B if you wish.

Part A involves mathematical calculations. Some skill in working with ratios and rate pairs is required.

Part B involves designing an experiment. You will not be required to do the experiment, just to develop a method.

Part A

On the surface of the Earth, a mass of 1 kg (1000 g) weighs just under 10 N (9.8 N to be exact). Think about a person with a mass of 60 kg on Earth. The weight of that person would be about 600 N. Now take that person to the Moon. The Moon's mass is only 1/6 that of the Earth. Therefore, the Moon's force of gravity is only 1/6 that of the Earth. When the person is weighed with a force meter on the Moon, the person would weigh only about 100 N (1/6 of 600 N). But the person's mass has not changed. The person's body still has 60 kg of matter.

Using this information and selecting information from the chart, *Distance from the Earth Versus Mass and Weight*, in Activity 3, calculate answers to the following questions.

1. A car has a mass of one tonne (1 t). This is equal to 1000 kg.

   a. What is the mass of the car in grams?

   ____

   b. What is the weight of the car in newtons?

   ____

   c. How much would the car weigh 6000 km above the Earth's surface?

   ____

   d. How much would the car weigh 18 000 km above the Earth's surface?

   ____

   e. What would the weight of the car be on the Moon?

   ____

   f. What would the mass of the car be on the Moon?

   ____

2. Using a bathroom scale, measure your mass in kilograms.

   a. What is your mass in kilograms?

   ___

   b. What is your mass in grams?

   ___

   c. What is your weight in newtons?

   ___

   d. How much would you weigh 6000 km above the Earth's surface (12 000 km from the centre of the Earth)?

   ___

   e. How much would you weigh 18 000 km above the Earth's surface (24 000 km from the centre of the Earth)?

   ___

   f. What would your weight be on the Moon?

   ___

   g. What would your mass be on the Moon?

   ___

Part B

It is easy to understand that the gravity of the Earth pulls on you. But it is difficult to imagine that, at the same time as the Earth is pulling on you, your own gravity is pulling on the Earth. Because your mass is so small by comparison with that of the Earth, you don't notice the effect of your gravity. Gravity also pulls you toward your desk and your desk pulls toward you. This, too, is hard to imagine. Both your own mass and that of your desk are too small for these gravitational pulls to be noticeable.

This is probably why people were not able to explain why things fell to the Earth before Sir Isaac Newton developed the explanation.

Develop a method for an experiment that would test the idea that all objects with mass attract each other. Since you won't have to actually do the experiment, you can choose any existing equipment. The important thing is that if you did do it, the experiment will actually work. State your answers under questions 3 and 4 which follow.

3. Briefly describe how to do the experiment.

4. Describe what observations from your experiment would support the idea that all objects with mass attract each other.

Discuss your answers with your learning facilitator.

Conclusion

In this section you learned about the idea of mass and how it is related to the force of gravity. You used graphs to show patterns between sets of data. You learned that

- The mass of an object does not change as it moves away from the Earth's surface (into space).
- The mass of an object does not change if measured somewhere other than the Earth's surface.
- Gravity acts between all bodies that have mass.
- Weight is a measure of the force of gravity.
- Weight changes if measured somewhere other than the Earth's surface.

When measuring mass, use a balance scale or some other scale that is calibrated in grams or kilograms.

When measuring weight, use a spring scale that is calibrated in newtons.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

Section

4

What Makes Things Move or Stay in Place?

In 1687, Isaac Newton published his ideas about gravity and motion. These ideas, more than 300 years later, are still supported by the evidence. The only exceptions to his ideas are objects travelling very, very fast – nearly the speed of light. (Three hundred million metres in one second – now that's fast!)

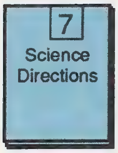
To understand fully and to use Newton's laws of motion requires the use of mathematics. You will not be required to develop a full understanding of Newton's laws. This section will help you develop an appreciation of what Newton's laws of motion mean.

Newton's laws include the following ideas:

- An object at rest (in other words, not moving) tends to remain at rest, unless a force is applied to it.
- A moving object continues to move with steady motion in a straight line unless an unbalanced force acts on it.
- An unbalanced force will start a stationary object in motion; it will also slow down, speed up, or change the direction of an object already in motion.

Right now, this probably seems confusing. But work through this section and the activities and you will begin to understand more than most people do about these 300-year-old ideas.

Activity 1: Balanced and Unbalanced Forces



When describing how forces are balanced, you must identify forces acting in opposite directions. Look at the illustration of the man fishing shown on page 176 of the textbook.

The upward force of buoyancy is balanced with the downward force of gravity.

If a person catches many fish and puts them in the boat, the mass of the boat and its load will increase. This means that the force of gravity will increase. At that moment the force of gravity and the force of buoyancy become unbalanced. As the boat sinks farther into the water, the buoyant force increases to balance the force of gravity. When the forces are balanced, the boat stops moving down, and it begins to float.

Another pair of balanced forces is the force of the fish swimming away from the boat and the force of the person pulling the fish toward the boat. When the forces are balanced, the motion of the fish and the fishing line does not change.

When one of the forces is greater than another force acting in the opposite direction, the forces are said to be unbalanced. Unbalanced forces will cause an object to move. The direction of the force depends on which force is greater. If the fish swims with the greater force, it will be able to swim away from the boat. If the force of the person is greater; then the person will pull the fish towards the boat.

Now turn to pages 146 and 147 of *Science Directions 7* and review the information under Balanced and Unbalanced Forces. Answer the following questions.

1. What is the upward force acting on the book in the illustration?

   ____

2. What is the downward force acting on the book?

   ____

3. Define *balanced forces.*

   ____

   ____

4. What force is causing the toboggan to move forward?

____

5. What force is tending to hold the toboggan back?

____

6. Define *unbalanced forces.*

____

____

Check your answers with your learning facilitator.

Activity 2: Inertia

In Module 2 you tried to build structures that did not move. The bridge you built was designed to have balanced forces. The downward force of gravity acting on the bridge and its load was balanced by the forces of compression and tension in the material used to build the bridge. When all the forces were balanced, you had a structure that did not move.

7 Science Directions

Look at the cartoon on pages 180 and 181 of *Science Directions 7* for an introduction to one of Isaac Newton's Laws of Motion.

Inertia: the tendency of a stationary object to remain stationary and of a moving object to continue moving unless an unbalanced force acts on it

Objects that are not moving are said to be at rest. Newton noticed that objects at rest did not move unless a force acted upon them. This resistance to change is called **inertia**. Newton also noticed that objects already moving continued to move at the same speed and in the same direction, unless an unbalanced force acted on them. This resistance to change is also called inertia.

Perhaps you have watched a trick in which someone pulled very quickly on a tablecloth. If done correctly, the tablecloth would be pulled off of the table without moving any of the dishes on it.

This is an example of inertia. The dishes did not move because very little force was exerted on them. Don't try this. The many times of practise that it requires is not worth the expense of the dishes broken during the practice. The Penny and Card Trick which follows will give you the opportunity to do a similar but less expensive trick.

This trick can be explained using the idea of inertia. Do the trick (it may take a little practice) by following the steps; then explain it by answering the questions.

Note: This experiment is based on the information given on page 181 of the textbook. You may wish to refer to the information given and to the diagram shown to help you understand how to do the trick better.

Materials You Need

- index card (or piece of heavy paper)
- penny
- water glass or beaker

Steps to Follow

Step 1: Place the index card on a table and put the penny on it.

Step 2: Pull the index card out from under the penny without moving the penny. To do this you must pull very quickly and in a direction parallel to the table top. Practise a few times until you are able to do it.

Step 3: Try setting other unbreakable objects on the index card and then pulling the index card away without moving the object.

Questions to Answer

1. a. Did the index card move?

   ____

   b. If it did, in which direction did it move?

   ____

2. a. Did the penny move?

   ____

   b. If it did, in which direction did it move?

   ____

3. Did you apply a force to the index card?

   ____

4. Did you apply a force to the penny?

   ____

5. Explain why this trick works, using Newton's ideas about objects at rest.

   ____

   ____

   ____

Steps to Follow (continued)

Step 4: Place the penny on the index card and put both on the glass.

Step 5: Flick the index card and see what happens.

Questions to Answer (continued)

6. a. Did the index card move?

   ____

   b. If it did, in which direction did it move?

   ____

7. a. Did the penny move?

   ____

   b. If it did, in which direction did it move?

   ____

8. Did you apply force to the index card?

   ____

9. Did you apply force to the penny?

   ____

Check your answers with your learning facilitator.

Activity 3: Stopping and Starting

Newton's ideas about inertia are very useful in explaining what makes things move and what makes things stay in place.

- Objects at rest do not move unless a force acts upon them.
- Objects already moving continue to move at the same speed and in the same direction, unless an unbalanced force acts on them.

7
Science
Directions

Think about these ideas as you examine the following examples on page 182 of *Science Directions 7*.

- Look at illustration A and read question 1 on page 182 of *Science Directions 7*.

In illustration A, Tina and the bus were at rest (not moving). The bus started to move because of the force of its tires on the road. Tina's body tended to stay at rest (not move forward) just like the penny on the index card. Since the bus was moving forward, Tina appeared to move backward. Actually, Tina remained at the same place until she bumped into the woman behind her. The woman behind Tina was hanging onto a pole attached to the bus. As the bus (and pole) started forward, the woman moved with the bus.

- Look at illustration B and read question 2.

In illustration B, the bus and Tina were moving at the same speed and in the same direction. When the driver applied the brakes to the bus, this was an unbalanced force that caused the bus to slow down. Tina continued to move forward until the unbalanced force of bumping into the man slowed her motion.

The two ideas of inertia explained Tina's movement.

- Objects at rest do not move unless a force acts upon them.

- Objects already moving continue to move at the same speed and in the same direction, unless an unbalanced force acts on them.

Now answer the following questions and develop your own explanations using these two ideas.

1. Look at illustration C. Tyler has to deliver the large pile of newspapers. As he starts out, the papers fall off the back of the wagon.

   a. Explain why the papers fell by describing the motions and forces that are involved.

   ____

   ____

   ____

b. What would you advise Tyler to do the next time he starts out?

____

____

____

7 Science Directions

2. Look at illustration D on page 182 of the textbook. Tyler puts the papers back on the wagon. He starts out again. The wagon wheel hits a rock and the papers fall off the front of the wagon.

   a. Explain why the papers fell this time by describing the motions and forces that are involved.

   ____

   ____

   ____

   b. What advice would you give Tyler now?

   ____

   ____

   ____

7 Science Directions

3. Look at the illustration for question 5 on page 182 of the textbook. Use wha you know about the inertia of moving objects to explain why it is always a good idea to do up your seat belt when in a car.

____

____

____

4. Place an index card on a table and put the penny on it; then pull the card forward suddenly. (This is a repeat of the card and penny trick.) The penny stays still or appears to move backward compared to the card. Which of the two ideas about inertia explains what happens?

____

____

____

5. Place the card on a table and put the penny on it again. This time, pull the card forward slowly, gradually increasing the speed, so that the penny stays on the card. Suddenly stop the card. The penny keeps moving forward. Which of the two ideas about inertia explains what happens?

____

____

____

Discuss your answers with your learning facilitator.

Activity 4: Measuring Friction

Do the following demonstration again, but this time for a different reason.

Lay an index card on a table and put a penny on it. Pull the card forward suddenly. The card slips out from under the penny. Lay the card on a table and put the penny on it again. This time pull the card forward slowly, gradually increasing the speed. This time the penny stays on the card.

Do you know why the penny slips off the card when pulled suddenly but stays on the card when the speed is gradually increased? The answer involves a force that you learned about earlier – friction. Friction is the force that always resists the motion of one object moving against another. When the card is pulled suddenly, the force of the forward motion is greater than the force of friction between the card and the penny. Since the forces are unbalanced, the penny slides (moves) along the surface of the card. When the card is pulled by gradually increasing the speed, the force of the forward motion is balanced by the force of friction between the card and the penny. Since the forces are balanced, the penny does not slide (move) along the surface of the card. Unbalanced forces cause a change in motion.

7
Science
Directions

Now turn to page 162 of the textbook. Read Measuring Friction. In the example involving the exercise mat, friction must be overcome before the mat can begin to move.

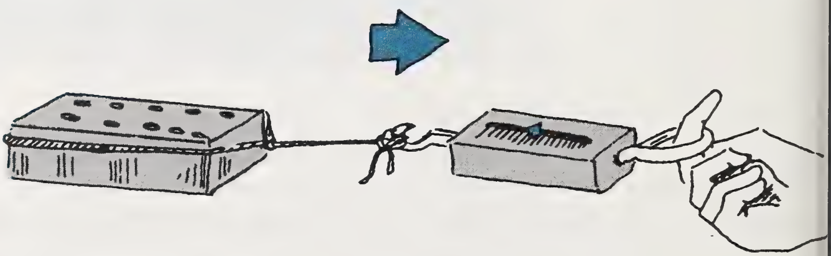
To measure the force of friction, you must measure the amount of force that is needed to unbalance the force resisting motion. Friction is the force that opposes motion. If you know how much force is needed to cause motion in one direction, you can infer that friction was working with equal force in the opposite direction.

Materials You Need

- two bricks or other small heavy flat objects with rough surfaces
- spring scale calibrated in newtons
- string
- piece of wood (30 cm × 50 cm)
- piece of linoleum (30 cm × 50 cm), or other smooth surface
- cooking oil

Steps to Follow

Step 1: Using the spring scale, pull the brick with a steady pull across the wood, as shown in the diagram.



Step 2: On the observation chart which follows, record how much force is needed to keep the brick moving. (It will take more force to start it moving than to keep it moving at a steady rate.)

Step 3: Pull the brick at a steady rate across the linoleum.

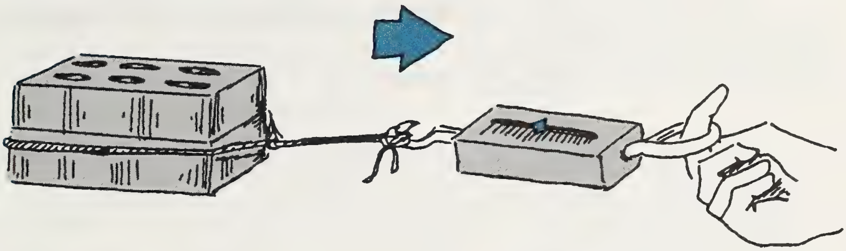
Step 4: On the observations chart, record how much force is needed to keep the brick moving.

Step 5: Spread a thin layer of oil on the linoleum.

Step 6: Pull the brick with a steady force across the linoleum covered with oil.

Step 7: On the observations chart, record how much force is needed to keep the brick moving.

Step 8: Repeat steps 1 to 7 using two bricks, stacked one on top of the other, as shown in the following illustration.



Observations

Surface	Force Needed to Pull One Brick (N)	Force Needed to Pull Two Bricks (N)
wood		
linoleum		
linoleum and oil		

Questions to Answer

1. Which surface resisted the motion of one brick with the greatest force?

____

2. Which surface resisted the motion of one brick with the least force?

____

3. a. Which surface provided the greatest force of friction?

____

b. How do you know?

4. What was the effect of doubling the number of bricks?

5. What was the effect of putting oil on the linoleum?

6. Predict the effect of pulling the brick over the wood if the wood was covered with sandpaper.

7. What is one way to reduce the force of friction between two surfaces?

8. What is one way to increase the force of friction between two surfaces?

9. Cars with front-wheel drive usually are able to move over snow and ice better than cars with rear-wheel drive. Why?

Discuss your answers with your learning facilitator.

Activity 5: Signs of Friction

7 Science Directions

Carefully read the information under Friction Summary and Why Friction Occurs on page 164 of *Science Directions 7*. Also examine the photographs. The photograph of polished steel on the top right corner of the page shows that even polished surfaces look rough when magnified under a microscope. The photograph of the bulldozer on the bottom right corner shows that the tracks on the bulldozer have huge ridges that stick out to increase the friction between the bulldozer and the ground. The force of friction keeps the bulldozer from slipping as it moves forward with great force.

7 Science Directions

Now read Signs of Friction on page 165 of the textbook. The information provides several examples of **inferences** that can be made regarding both the useful and unwanted effects of friction. Also examine the illustrations on the same page. Although you cannot see friction, you can see its effects. Based on what you have found out about friction in this module, you could **infer** that each of the objects in the illustration has worn out because of friction.

Inferences: possible explanations for something observed

Infer: to provide a possible explanation for something observed

Signs of friction and ways to reduce friction are everywhere. In this activity you will look for evidence that the force of friction has been at work and for ways to reduce the effects of the force of friction.

7 Science Directions

1. Hard surfaces that move against each other in a machine are often protected by a **bearing**. Look at the illustration of the bearings in a skateboard shown on page 166 of the textbook. How do bearings help reduce the effects of friction?

____

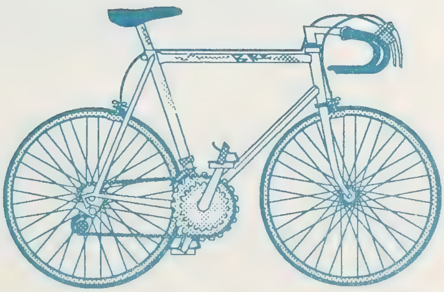
____

Bearing: a moving part of machinery containing balls or rollers that reduce friction

Lubricants: substances that help to reduce friction between moving parts in a machine

2. **Lubricants** such as oil are used to reduce friction. Identify two spots on a bicycle on which you could use oil to reduce friction.

   a. Circle the spots on this picture of the bicycle.



b. Why did you choose these two spots?

3. Keep your hands together tightly while you rub them quickly back and forth several times. You should feel another effect of friction – heat. Describe two other examples in which friction causes heat.

4. Look at the bottom of one of your shoes. Describe evidence of friction.

5. Look at a tire on a bicycle or on a car. Describe evidence of friction.

Check your answers with your learning facilitator.

Activity 6: Action and Reaction

7
Science Directions

Study the information under Action and Reaction on page 184 of *Science Directions 7* and More Examples of Action and Reaction on page 185. The examples described on these textbook pages support Newton's law that states "for every action, there is an equal and opposite reaction."

ction and reaction: every time n object exerts a force (action) n another object, the receiving bject exerts an equal force eaction) in the opposite irection

Do either Part A or Part B.

Part A is a demonstration of an action-reaction pair using a toy car. It is based on the information given under Equal and Opposite Reactions on page 184 of the textbook.

7
Science Directions

Part B is a demonstration of an action-reaction pair showing how a rocket moves. It is based on the information given under Investigating Action-Reaction Forces: Demonstration on page 185 of the textbook.

Part A

Note: You do not need to complete Part A if you wish to do Part B.

Materials You Need

- sheet of stiff cardboard (10 cm × 20 cm)
- marbles (25 or more)
- wind-up or battery-powered toy car or truck

Follow the instructions and answer the questions.

- Put the marbles close together on a smooth surface, and carefully lay the cardboard on top of them.

redict: to tell in advance what ight happen on the basis of revious observation and xperience

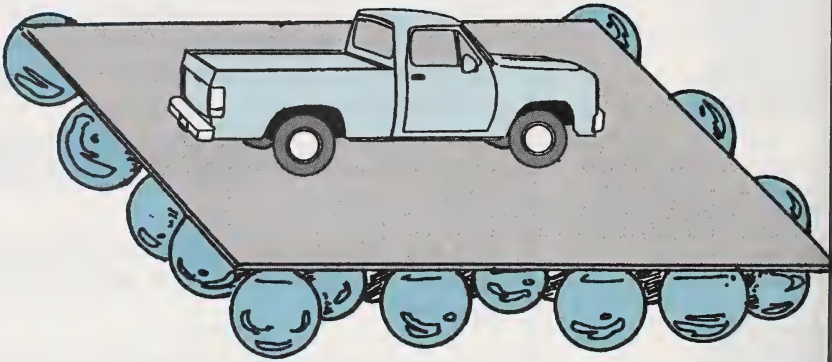
1. **Predict** what will happen if you wind up the car/truck and place it on the cardboard.

   Prediction:

   ____

   ____

- Wind up (or turn on) the toy car/truck; then set it carefully on the cardboard.



2. Record your observations here.

3. In what direction do the wheels push on the cardboard?

4. How does a car/truck on a road move forward? Explain in terms of action and reaction?

Check your answers with your learning facilitator.

Part B

Note: You do not need to complete Part B if you have already done Part A.

Materials You Need

- two small (5 cm) binder rings
- a long balloon
- string
- tape
- two chairs
- spring clip

Steps to Follow

7
Science Directions

See the illustration at the bottom of page 185 in *Science Directions 7* to help you set up this demonstration.

Step 1: Blow up the balloon and close the end with a spring clip.

Step 2: Tape the two rings onto the balloon and run the string through them.

Step 3: Arrange the chairs about 4 m apart and tie the string between them.

Step 4: Pull the balloon to one end of the string and release the clip.

Questions to Answer

5. What action takes place first?

____

6. What is the reaction that takes place as a result?

____

7. In which direction is the first action, and in what direction is the reaction?

first action: ______________________________________

reaction: ____

8. Explain how this demonstration serves as a model of action and reaction forces in a rocket.

____

____

____

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Something that is not moving will only start moving if a force is applied to it. A soccer ball rests on the ground until you kick it. The kick is a force that starts the ball moving. If you were to kick a car, the car would not start moving. This is because the force of friction between the car and the road is greater than the force of your kick. If a large truck crashes into the car, the car will move. This is because the force of the truck crashing into the car is greater than the force of friction between the car and the road. Forces acting in opposite directions must be unbalanced to start something moving.

The tendency for something to remain at rest until a force acts on it is called inertia. An object that has a large mass has more inertia than an object that has a smaller mass.

7
Science
Directions

Look at the illustrations on the top half of page 183 in the textbook. In illustration A, the boy is unable to push the cow because he cannot push with a force greater than the friction between the cow and the ground. However, in illustration C, the boy is able to push the small calf because he is able to push with a force greater than the friction between the calf and the ground. The boy is able to overcome the inertia of the calf, but he is unable to overcome the inertia of the cow.

Inertia also keeps moving objects moving. An object that has a large mass is harder to stop moving than an object that has a smaller mass.

7
Science Directions

In illustration B on page 183 of the textbook, the boy cannot stop the cow because he is not able to push with a force greater than the force of the moving cow. He is unable to balance the forces, so the cow continues to move. However, in illustration D, the boy is able to stop the small calf because he is able to push with a force greater than the force of the moving calf. He is able to balance the forces. Balanced forces mean that no motion will occur.

Forces that are always with you on Earth are gravity and friction. Gravity is the force that pulls you toward the Earth. Friction is the force that slows things down or stops motion.

You will now try a demonstration to show how mass affects inertia. You will need the following materials:

- table tennis ball
- golf ball

Follow the instructions and answer the questions.

1. Predict what will happen when you place a golf ball on a smooth floor and roll a table tennis ball into it.

   Prediction:

   ____

   ____

2. Try it. Then record your observations.

   Observations:

   ____

   ____

   ____

3. Predict what will happen when you roll the golf ball into the table tennis ball.

   Prediction:

   ____

   ____

4. Try it. Then record your observations.

   Observations:

   ____

   ____

   ____

5. Explain your observations in questions 2 and 4 in terms of what you have learned about mass and inertia.

   ____

   ____

   ____

7 Science Directions

6. Look at the illustration of the truck and car shown on page 183 of the textbook. The truck and car are travelling at the same speed. They are both going to brake at the line shown. Which do you think will require more braking force to bring it to a stop? Why?

   ____

   ____

   ____

Check your answers with your learning facilitator.

Enrichment

You may choose to do only Part A or Part B, but you may do both Part A and Part B, if you wish.

Part A is a thought experiment about the effects of friction.

Part B is a demonstration to show how satellites orbit the Earth.

7
Science Directions

Part A: Effects of Friction

This thought experiment is based on the information given on pages 168 and 169 of *Science Directions 7*. Read the textbook information carefully; then answer the following questions.

1. Imagine that it is a beautiful, warm, and calm day. You set out on a bicycle ride.

   a. What do you feel against your skin, hair, and clothes as you pedal along?

   ____

   b. How does what you feel change as you move faster?

   ____

2. Imagine you are at the beach with a friend. You decide to have a water race.

   a. How does running in the water compare with running on land?

   ____

   ____

   b. What two surfaces are moving against each other as you move in water?

   ____

   ____

   c. Why is it harder to run in water than in air?

   ____

   ____

3. Imagine that you are in a space shuttle as it returns to Earth. The engines are fired briefly to slow the craft down to 28 000 km/h. At this speed, the shuttle leaves orbit and starts to fall toward Earth. When the shuttle has fallen to a distance of 130 km above the Earth's surface, you can hear air beginning to brush the sides of the shuttle. Through the window you are able to see that the bottom part of the shuttle has started to glow with a red colour.

   a. Why is the shuttle starting to glow?

   b. The shuttle does not need its rockets to slow down its descent. What force will help it slow down as it travels toward the Earth's surface?

Check your answers with your learning facilitator.

Part B: Satellite Motion

Part B is based on the information given on pages 186 and 187 of *Science Directions 7*. Read the textbook information carefully.

A satellite follows a curved path around the Earth because of two balanced forces:

- Its forward motion pulls it in a straight line away from the Earth.
- The Earth's gravity pulls it down toward the Earth.

You will now construct a model of the flight path of a satellite in orbit. This model will demonstrate the two balanced forces. Do the following:

- Obtain the materials listed on page 187 of the textbook.
- Carry out steps 1 to 5 of the Procedure on page 187 of the textbook. (The mass of the washers in step 5 simulates the pull of the Earth's gravity.)

Caution

Everyone should be at least 3 m from the model when it is being demonstrated.

- Answer the following questions.

1. What object in this model represents the satellite?

___

2. What object in this model represents the Earth?

___

3. a. What force was pulling the stopper closer to the tubing?

   ___

   b. What force pulls a real satellite closer to the Earth?

   ___

4. When more washers are added, do you need to increase or slow the speed of the stopper to keep it the same distance from the tubing?

___

5. As a real satellite speeds up, what should happen to its orbit around the Earth?

___

___

6. The Moon is a satellite of the Earth. It has been orbiting the Earth for millions and millions of years.

   a. What force keeps the Moon from moving away from the Earth?

   ___

b. What would happen if the Moon started to slow down in its orbit around the Earth?

7. The Earth is a satellite of the Sun. What keeps the Earth in an orbit around the Sun?

Check your answers with your learning facilitator.

Conclusion

In this section you learned about Newton's laws of motion.

- An object at rest tends to stay at rest unless a force is applied to it.
- A moving object continues to move with steady motion in a straight line unless an unbalanced force acts on it.
- An unbalanced force will start a stationary object in motion; it will also slow down, speed up, or change the direction of an object already in motion.

Using these laws you should be able to predict the motions and pathways of moving objects, if you know what forces are acting on the objects.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 4.

Note: After you have completed the assignment for Section 4, read the Module Summary which follows.

MODULE SUMMARY

You learned that balanced forces make things stay in place, and unbalanced forces make things move. Knowing what forces are acting on an object allows you to predict its motion.

Mass and weight are related, but they are measurements of different things. Because they are different, they have different units; grams for mass and newtons for weight.

Weight is a measure of the force of gravity. Gravity is a force between matter. Gravity is a force that must be considered when predicting the motion of any object, anywhere.

Another important force is friction. Friction opposes motion. Friction exists whenever two surfaces touch. Friction occurs for solids, liquids, and gases.

Other forces are magnetic, buoyant, and electrostatic. Like all forces, they cannot be seen. But their effects can. All forces can be measured with a spring scale that is calibrated in newtons.

Sir Isaac Newton was the first person to explain motion using the idea of force. He developed laws of gravitation and motion over 300 years ago. His ideas are still used to explain force and motion.

Appendix

Glossary

Action and reaction
- every time an object exerts a force (action) on another object, the receiving object exerts an equal force (reaction) in the opposite direction

Balance scale
- an instrument used for measuring the mass of an object

Balanced forces
- two forces of equal strength acting on an object in opposite directions

Bearing
- a moving part of machinery containing balls or rollers that reduce friction

Buoyancy
- the upward force that fluids exert

Calibrate
- to mark a scale of units, such as centimetres or newtons, on a measuring device, such as a ruler or a force meter

Data
- factual information (The word *data* is plural; the singular is *datum*.)

Electrostatic force
- the electricity produced when two surfaces are rubbed against each other
A common word for electrostatic force is static.

Fluid
- something that flows
Gases and liquids are fluids.

Force
- a push or a pull

Force meter
- an instrument for measuring force

Friction
- a force that results when the surface of an object moves against the surface of another object

Gravity
- a force that pulls anything with mass toward anything else with mass

Hypothesis
- an idea or model that provides a possible explanation or why something occurs in the natural world

Inertia
- the tendency of a stationary object to remain stationary and of a moving object to continue moving unless an unbalanced force acts on it

Infer • to provide a possible explanation for something observed

Inferences • possible explanations for something observed

Lubricants • substances that help to reduce friction between moving parts in a machine

Magnetic force • a force that acts on some objects near a magnet

Magnetism • a characteristic of some materials that cause them to be attracted to some metals
Materials that have this characteristic are called magnets.

Mass • the amount of matter in an object
Mass is usually measured in grams and kilograms. An object's mass remains the same whether the object is on Earth or in space.

Matter • anything that has mass and occupies space
All gases, liquids, and solids are matter.

Newton • the standard SI unit for measuring a force

Predict • to tell in advance what might happen on the basis of previous observation and experience

Scale • the equal divisions marked on a measuring device

Spring scale • a type of force meter
It is an instrument for measuring the strength of a force.

Static • the common word for electrostatic force

Unbalanced forces • forces of different strengths acting on an object in opposit directions
Unbalanced forces cause a change in the motion of the object they are acting on.

Volume • the amount of space taken up by an object

Weight • the amount of force that is exerted on an object by gravity

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